Preliminary: Worldwide Optimal PICS Search
North Africa Version

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Outline.

- Google Earth Engine
- Pilot study in North Africa
- Finding PICS across the dynamic range

Google Earth Engine – Overview

- GEE is a platform developed by Google to address the "big data" problems of global earth monitoring.
- Does this by trying to reduce (or remove) the effort needed stage / handle / process vast global remote sensed data.
- In partial is the fact they have all of Landsat Archive on spinning disk, and a small 5000 node cluster directly attached.
- Two interfaces are available, an online "play ground" interface, for easy experimentation of new algorithms, and a python API interface, which allows for direct interface to the cluster from remote systems (IP Lab has direct access)

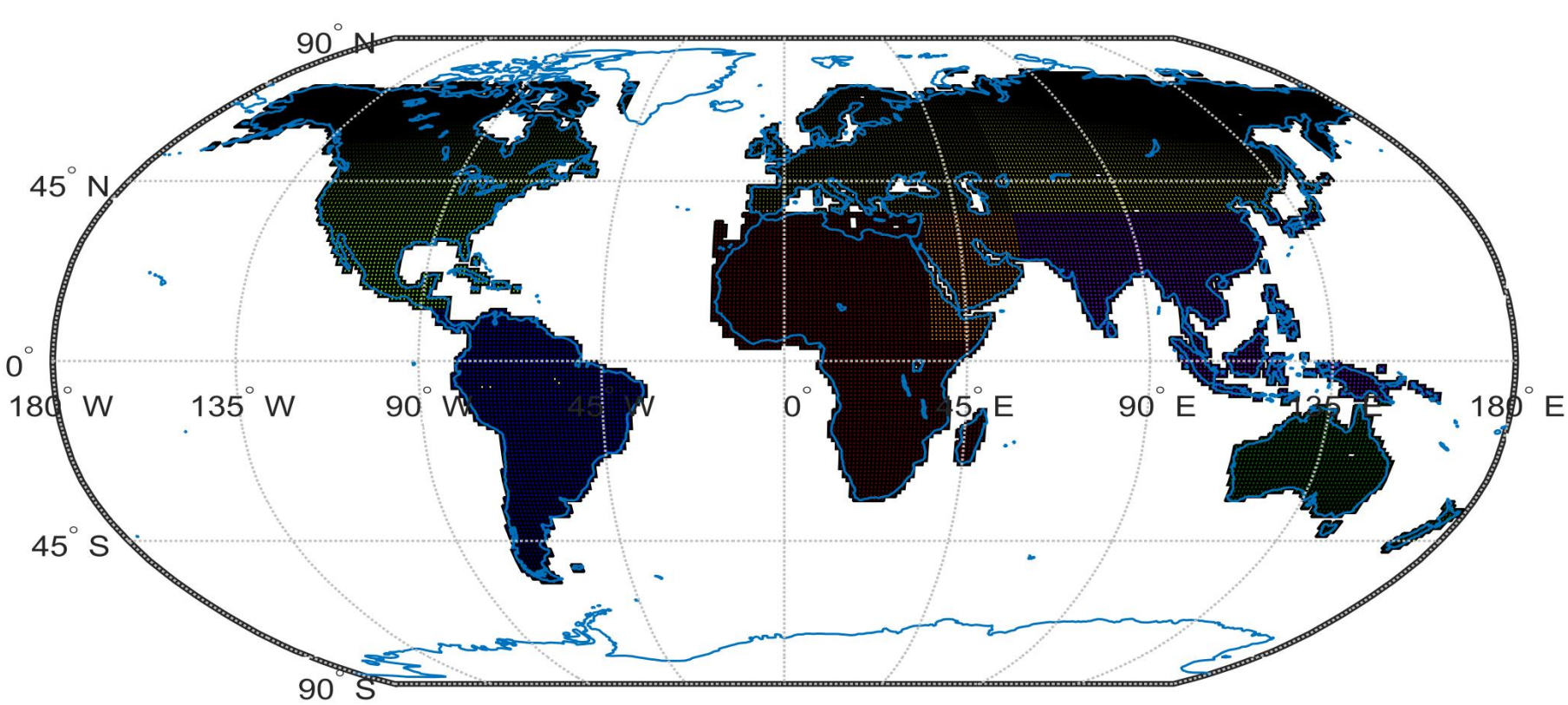
WOPS overview

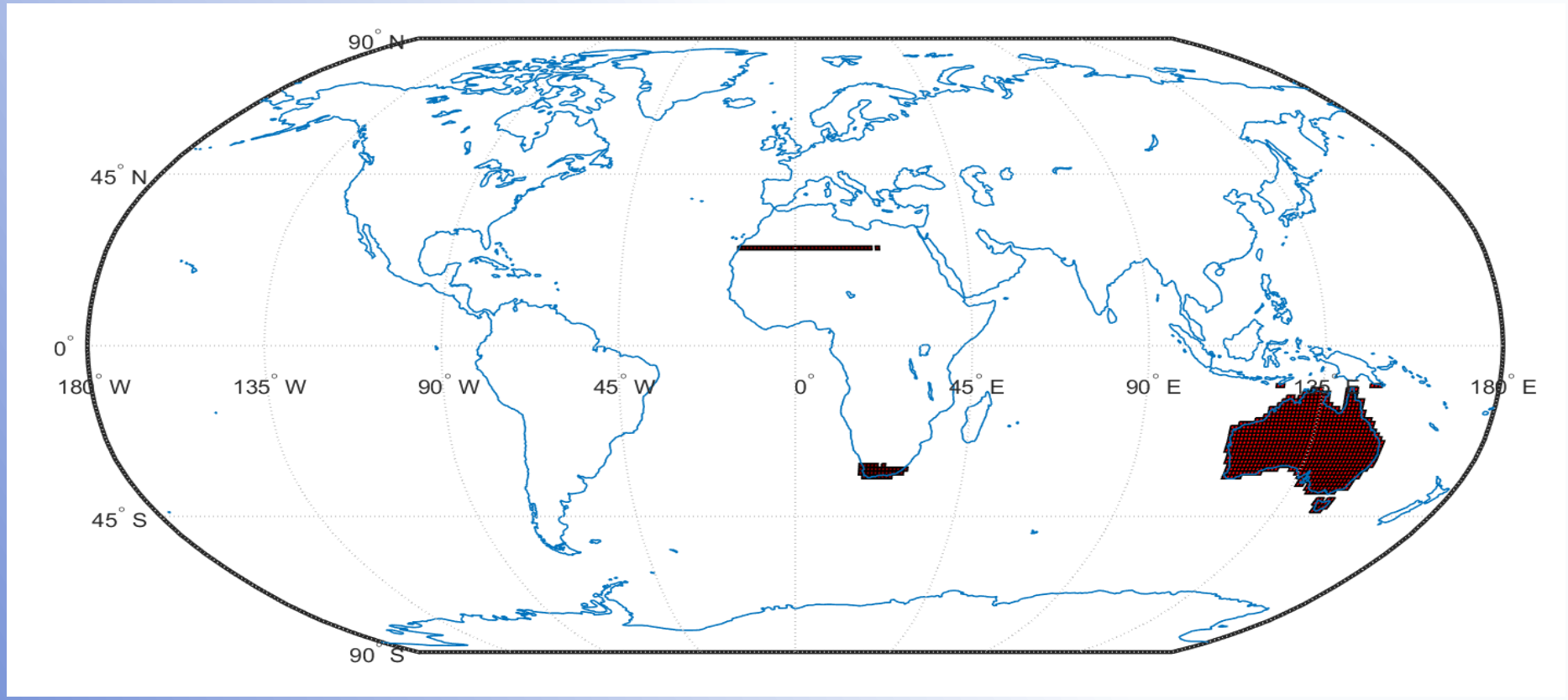
- Started off as a "joke" – "Won't it be nice to put a 'worm' in the EROS archive, to crawl through and find invariant regions globally?"
  - With GEE we are able to do this.
- With GEE we expanded the scope to do a world wide PICS search, but to also search for PICS at various intensity levels.
  - The goal is to be able to increase the frequency at which any given system sees a PICS site, **and** evaluate it performance across the dynamic range
- The process in principle is simple
  - Look at every single pixel on the globe, screen for cloud / saturation / etc.
  - Develop a temporal mean / std / uncertainty understanding for every pixel on the planet.
  - Then filter the data based on it's life-time stability, and for it's relative intensity

WOPS current status

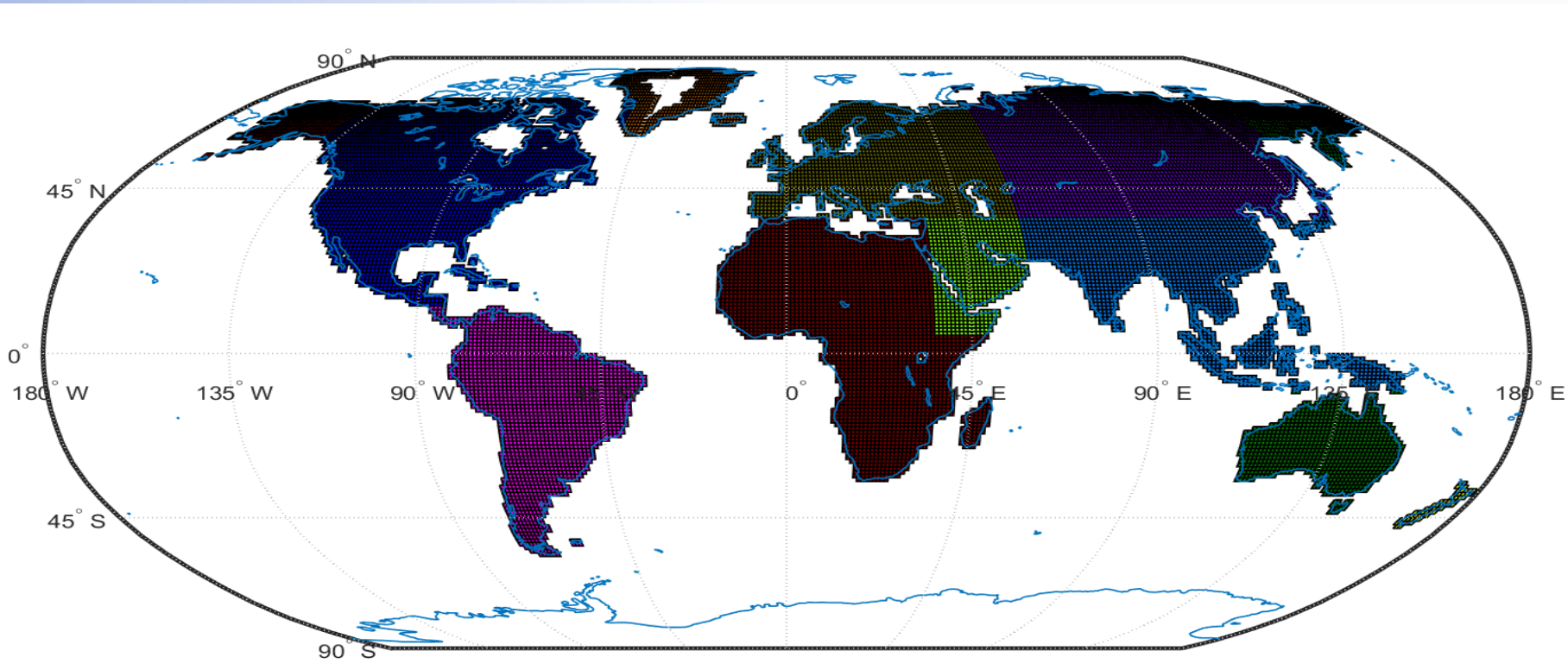
- The system is "controlled" by our server at SDSU using python scripts, makes requests to GEE and all results are sent back to SDSU
- Currently have processed the entire Landsat 8 archive (as of last month).
  - Lots of data, too much to handle
    - This required us to "degrade" the Landsat pixel to 300 meter, this save months of process time, and terabytes of disk space
    - Took ~5 weeks to process
- Landsat 5 is complete
    - More data but due to efficiency improvements in our coding ~3-4 weeks of total processing time was required
- Next in queue Landsat 7
    - ~10 % complete

L8 WOPS completion map




90° N
45° N
0°
180° W
135° W
90° W
45° W
0°
45° E
90° E
180° E
45° S
90° S

L5 WOPS completion map



Initial Pilot study

Wanted to get a feel for the data pile, so started simple

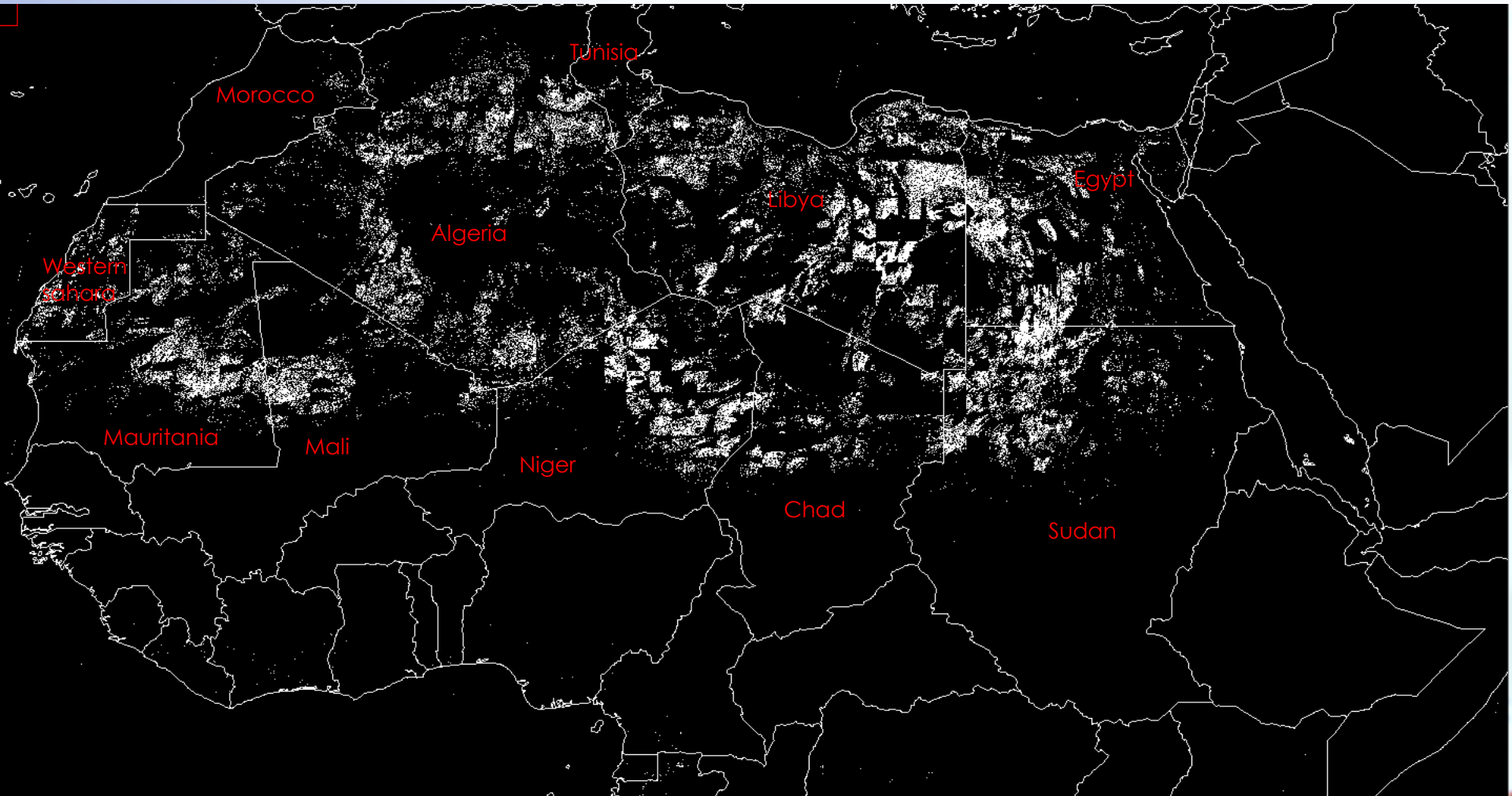
- The data comes out of the GEE system as 1 degree by 1 degree "chips" this means for the globe ~17000 chips.
  - GEE handles the temporal trending, locally we need to evaluate the results.
- Pixel reflectance values of only less than and equal to 5% uncertainty level .
- For each individual "chip" a optimal reference value was chosen
  - correspond to the most frequent reflectance level that met the temporal uncertainty levels

The point of this is to simply evaluate are their areas outside the current "known" PICS areas that we can consider as PICS?

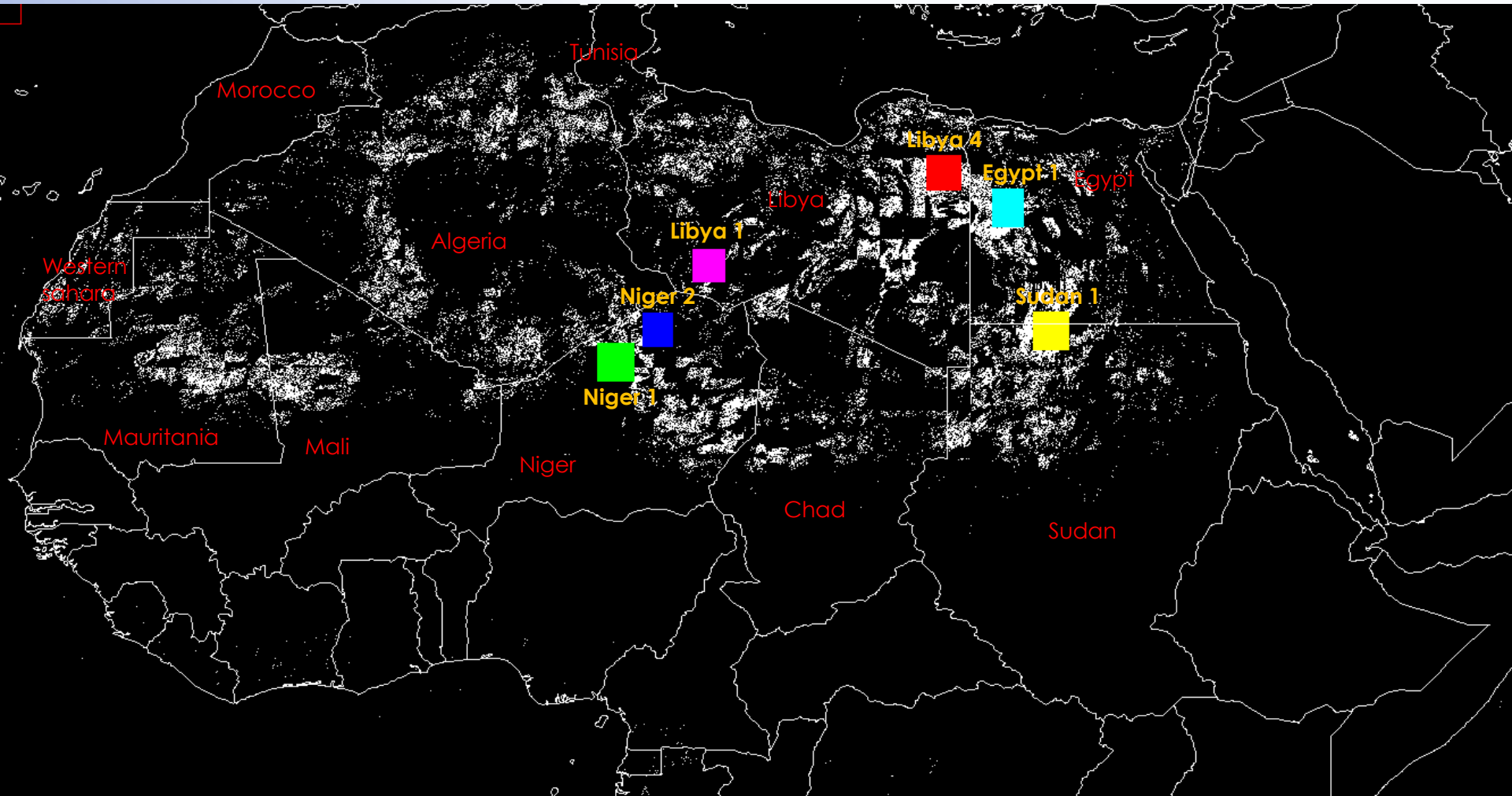
For ease of display let's zoom into our favorite location, North Africa.

Map of North Africa

Initial Pilot study – North Africa



Current “favorite” PICS Locations

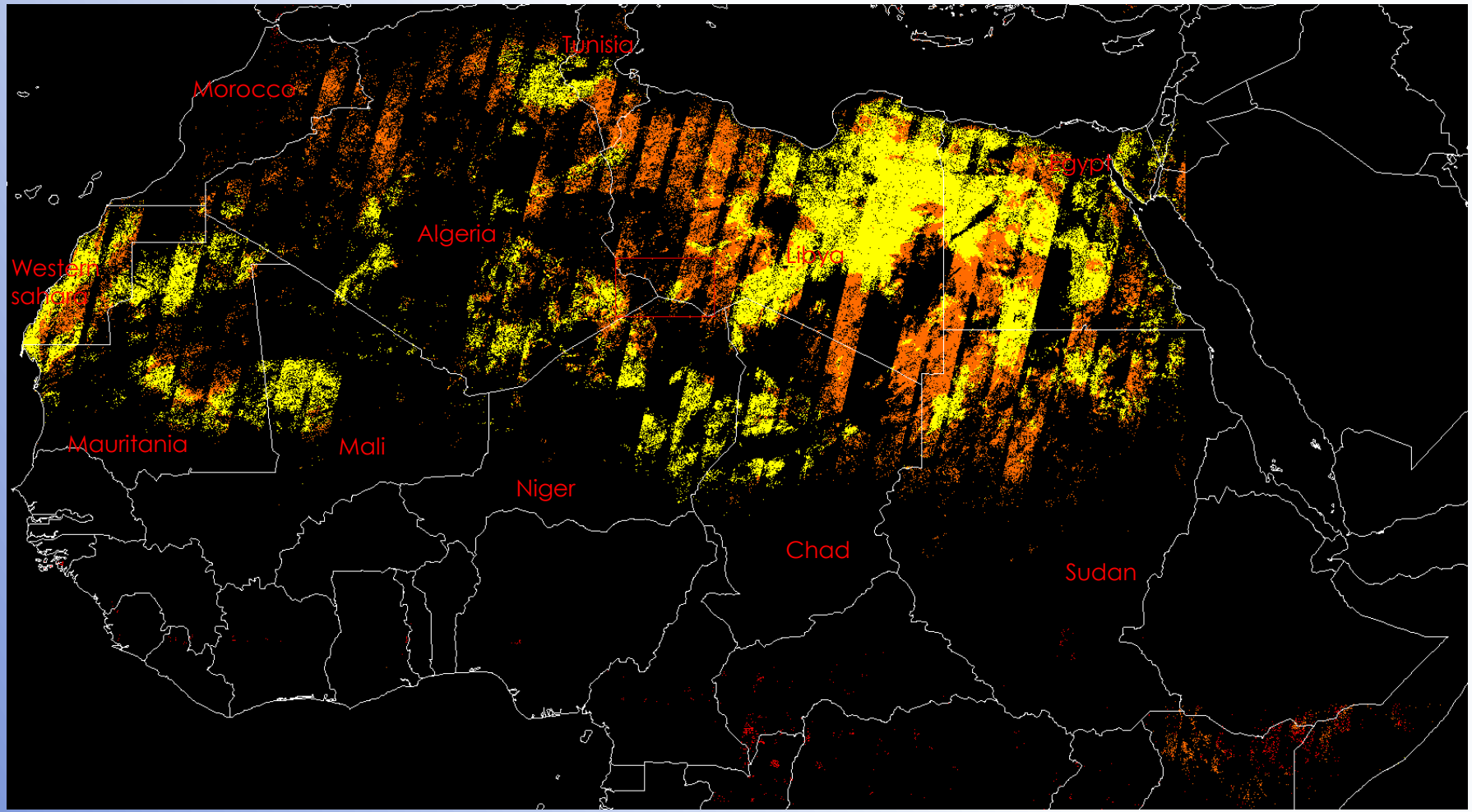


Full analysis

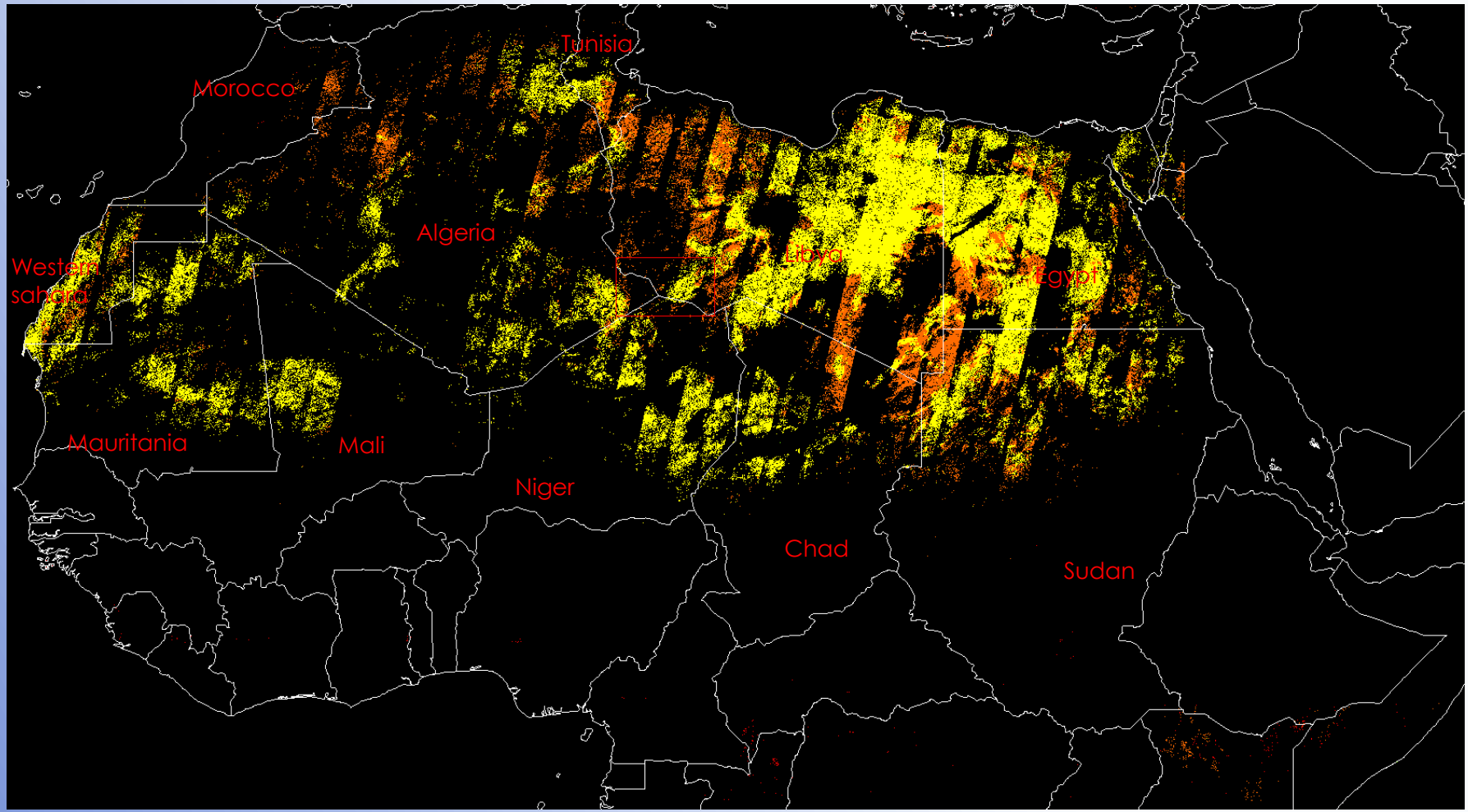
- Encouraged by the pilot, moved forward with the "master" plan of finding "all" PICS in the world, and to find PICS at various intensity levels -> Hunt for the "dark PICS"
  - Evaluated every pixel on the globe at various intensity levels, 10% to 90%,.
  - Temporal uncertainty less than and equal 3%.
    - We will tighten this as we move forward, but we want to get sense of where PICS "live" and "work"
  - With the reference reflectance levels 3% tolerance used, with broader reflectance range or window.

- Picture time……

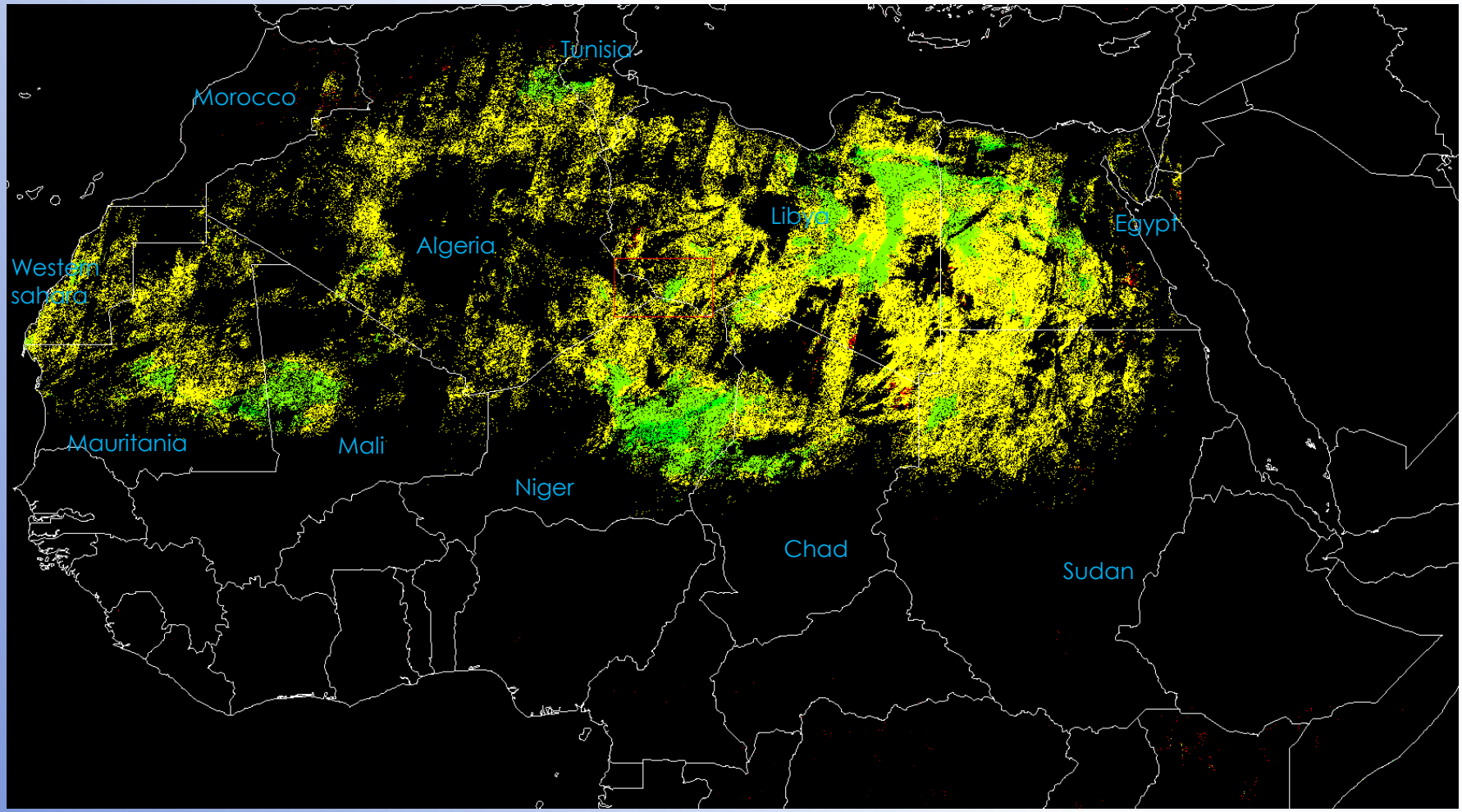
Band 1(Coastal)– Red (~5%) -> Green (~40%) -> Blue (~65%)



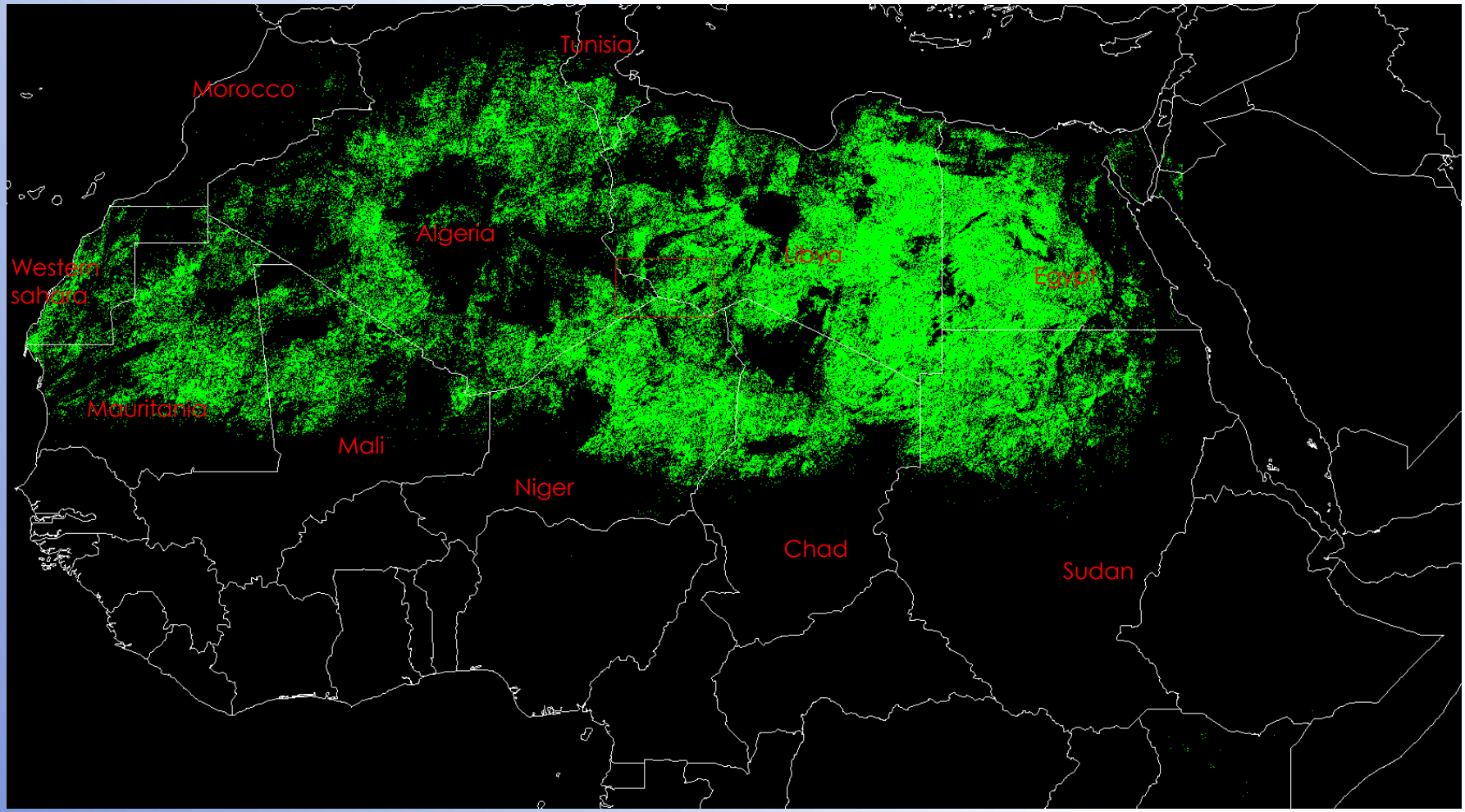
Band 2(Blue)– Red (~5%) -> Green (~40%) -> Blue (~65%)



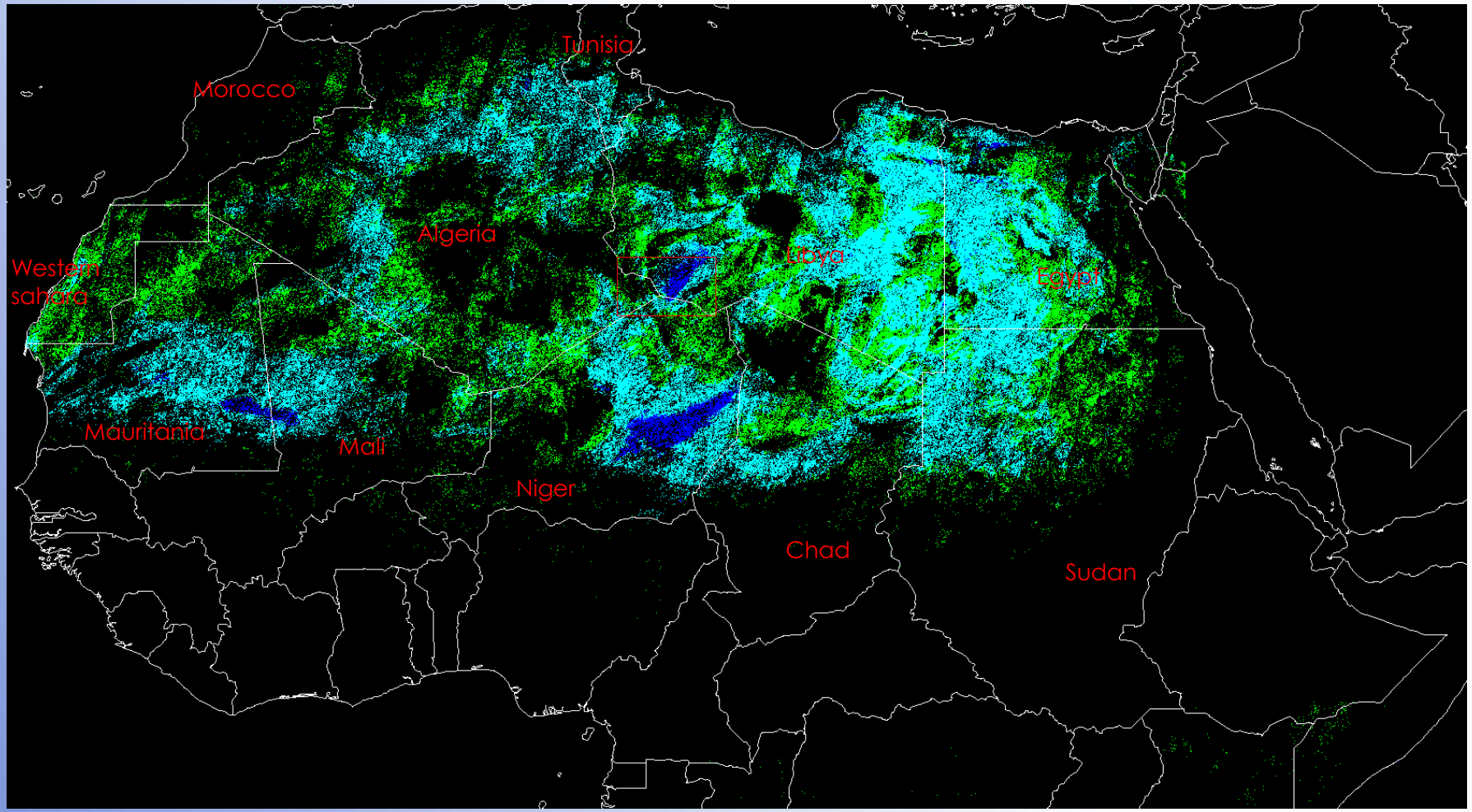
Band 3(Green)– Red (~5%) -> Green (~40%) -> Blue (~65%)



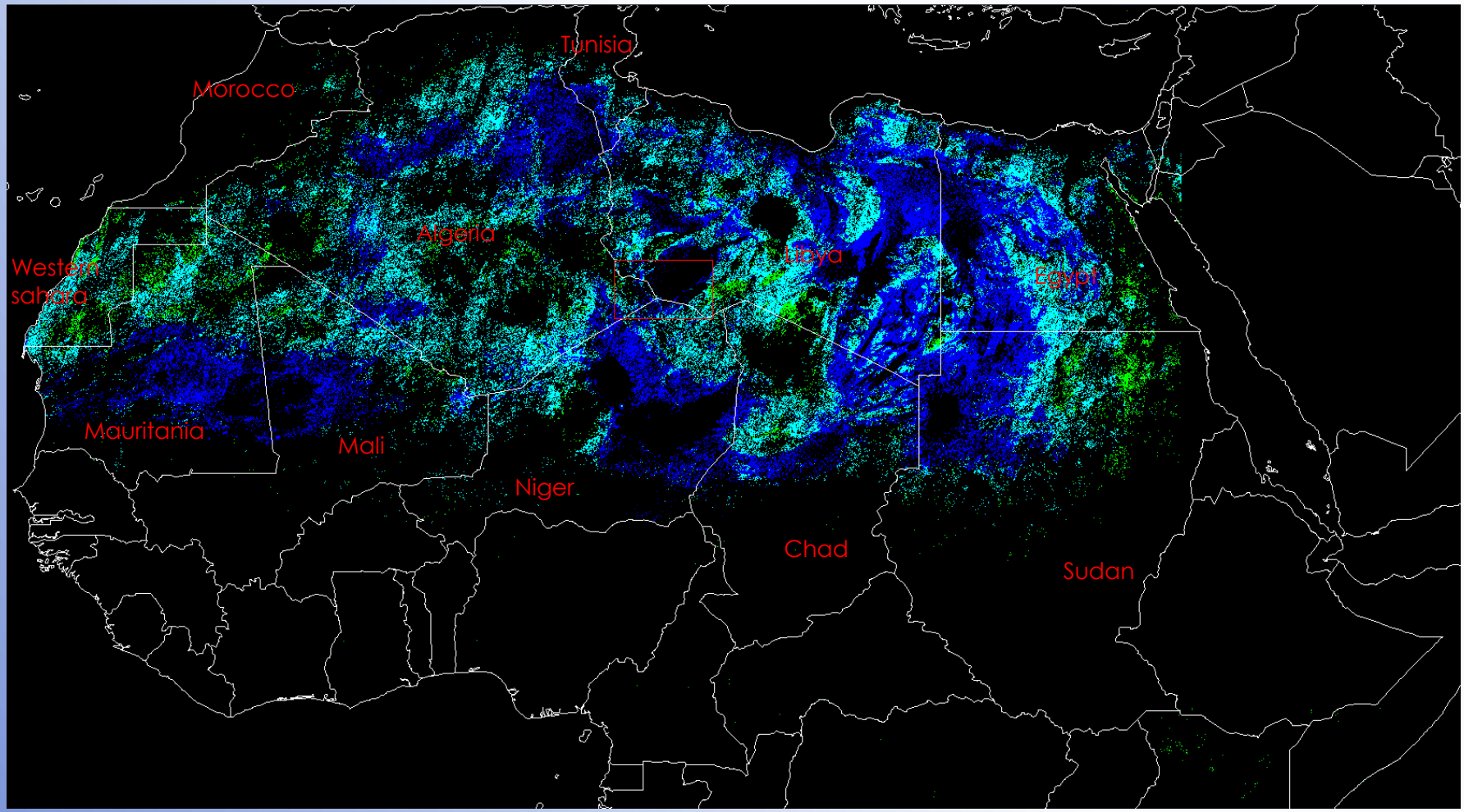
Band 4(Red)-Red (~5%) -> Green (~40%) -> Blue (~65%)



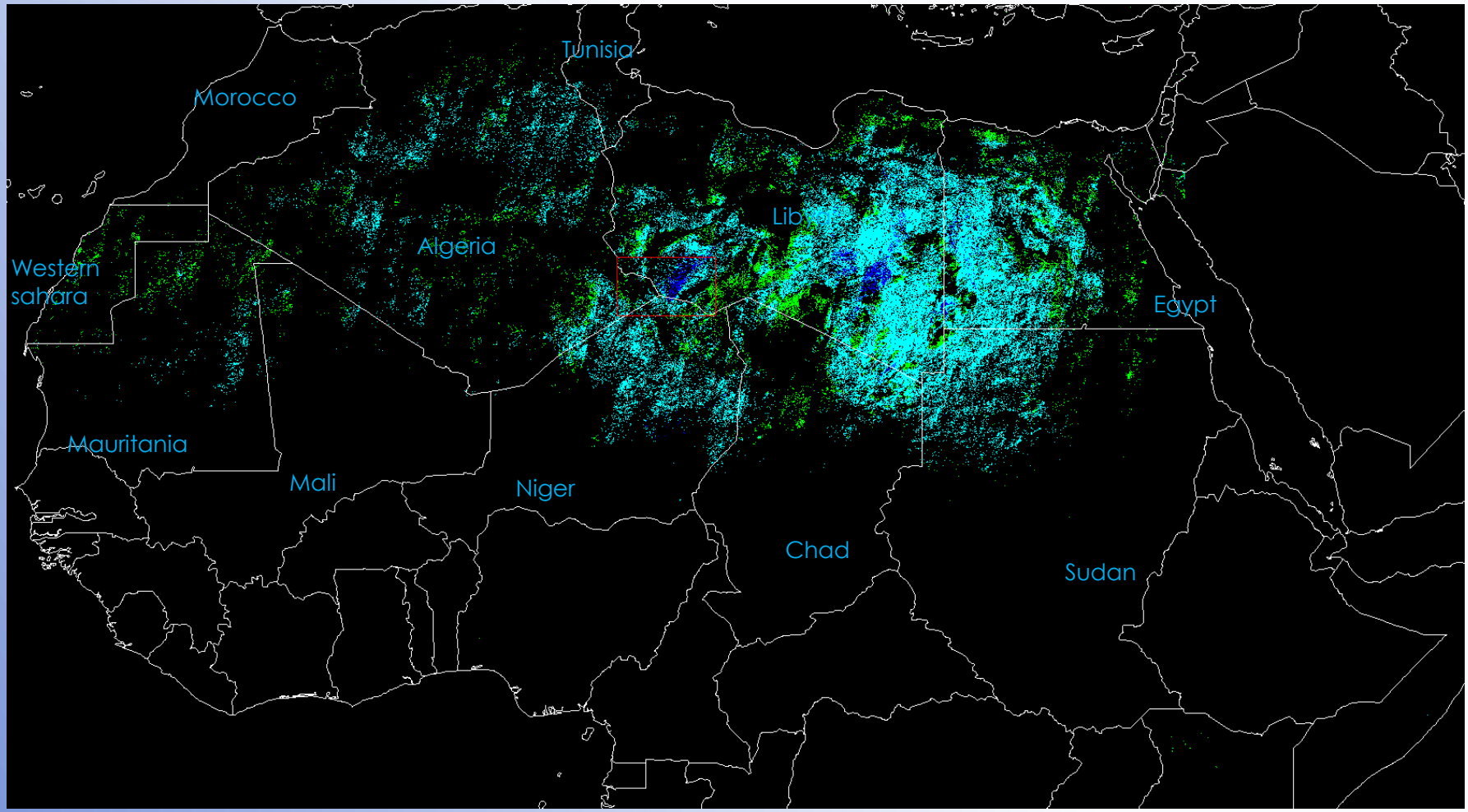
Band 5(NIR)-Red (~5%) -> Green (~40%) -> Blue (~65%)



Band 6(SWIR1)-Red (~5%) -> Green (~40%) -> Blue (~65%)

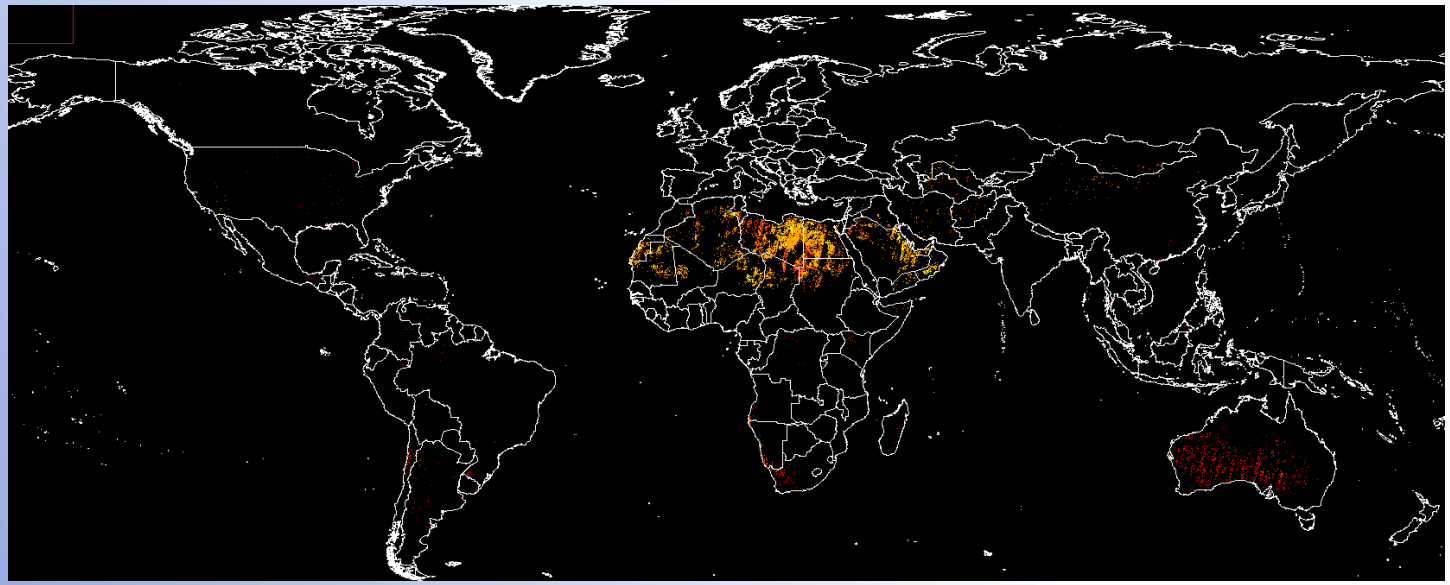


Band 7(SWIR2)-Red (~5%) -> Green (~40%) -> Blue (~65%)



Taste for the world

- At this resolution it's are to see, but areas of interest exist in all continents, and at various intensity levels.



Current Findings

- The initial search has shown vast areas which show 3% or better stability over a range of reflectance, these include
  - Much of North Africa
  - South Africa
  - Australia
  - Mongolia / West China
  - South American
  - North America
- These area will be further compared and investigated to determine optimal “regions”

Conclusion

- Seems there are more areas in the world that could be used for calibration, some bands (at least for north Africa) can be evaluated across a large portion of their dynamic range.
- Some exciting possibilities to move past WRS based PICS and move towards a “world” reference.

Future Work

- Finish off the globe, determine if for all bands is there a possibility for dynamic range evaluation
- Compare the results from Landsat 5 / 7 / 8 and determine if these new PICS are stable for extended period of time
- Develop world reference maps!!!